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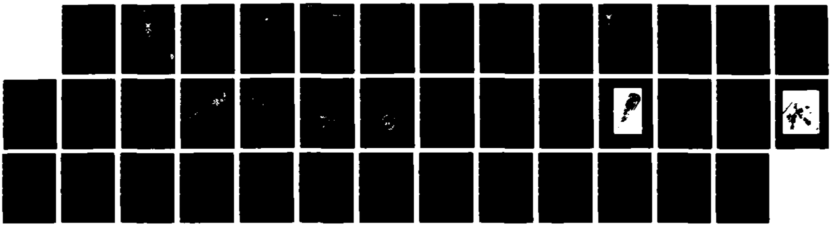

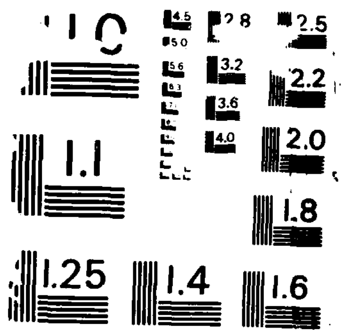

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STUDENT REPORT

THE SOVIET MIR SPACE STATION

MAJOR THOMAS E. SNOOK 88-2445

"insights into tomorrow"

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REPORT NUMBER 1988-2445

TITLE THE SOVIET MIR SPACE STATION

AUTHOR(S) MAJOR THOMAS E. SNOOK, USAF

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SPONSOR ROSS L. McHENRY, GM-14, NASA/JSC-FM45

Submitted to the faculty in partial fulfillment of requirements for graduation.

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The purpose of this paper was to determine if the Soviet MIR space station represents a significant advance when compared to the Soviets' preceding Salyut 7 space station. A description and comparison of the physical features of Salyut 7 and MIR are presented. A discussion and analysis of the scientific, commercial, military and political uses or missions of the Salyut 7 and MIR space stations are included. The MIR space station is determined to be a significant advance relative to the Salyut 7 space station.

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PREFACE

This paper was an introduction to the Soviets manned space station program. Specifically, the Soviet Salyut 7 space station and MIR space station were discussed and evaluated. The paper concluded that the MIR space station represents a significant advance in capability as compared to the preceding Salyut 7 space station. The paper was intended to inform other military officers of the general design and operation of the Soviet's space station. This information could be of increasing importance as we find ourselves increasingly dependent on space operations.

Special recognition should be given to Major Bruce Thieman, ACSC/Space Operations Studies for his outstanding guidance and encouragement for this project. Special thanks should also be given to Mr. Ross Leroy McHenry, distinguished engineer and manager at NASA-JSC who provided encouragement, support and sponsorship for this study. Also special thanks to Mr. James Oberg, distinguished author on Soviet space activities and outstanding engineer for McDonnell Douglas at NASA/JSC for his expert comments.

This project was active from October 1987 to March 1988. The study was limited to unclassified information and to approximately 100 man-hours by the author.

ABOUT THE AUTHOR

The author, Major Thomas E. Snook, USAF, was born in 1950 in Houston, Texas. He graduated from the University of Houston in 1972 with a Bachelor of Science Degree in Mechanical Engineering. In 1973, he was commissioned into the Air Force through the Officer Training School and was assigned to the Air Force Rocket Propulsion Laboratory (AFRPL) where he worked extensively with satellite propulsion development and testing. In 1978, he graduated from the USAF Test Pilot School Flight Test Engincer Course. From 1979 to 1983 he worked in the 475th Test Squadron for Operational Test and Evaluation (OT&E) of fighter interceptor aircraft. From 1983 to 1984, he attended the University of Texas, obtaining a Masters of Science degree in Aerospace Engineering. From 1985 to 1987, he was assigned to the NASA Johnson Space Center where he worked Advanced Spacecraft Guidance and Navigation studies. In August 1987 he was enrolled in the Air Force Command and Staff College.

Major Snook has authored technical reports on satellite propulsion, a variety of aircraft flight tests and spacecraft guidance studies. The most significant of these are listed below.

1. "Evaluation of Walter Kidde 300 LBF Hydrazine Thruster." AFRPL-TR-75-66, September 1975.

2. "Vertical Orientation Testing of Rocket Research Corporation 1300 NT Hydrazine Thruster." AFRPL-TR-77-78, February 1978.

3. "Flight Test of Modified F-106/MB-1 Ejector Rack." ADCOM/AFLC/ADWC Project 19-01, July 1980.

4. "Infrared Search and Track Capability Flight Test." AFSC/AFAL/ADCOM/ADWC/SAC Project 79-07, January 1981.

5. "F-15 RM-30/Low Cost Tow Target QOT&E." TAC Project 82B-187A, April 1983.

6. "Monte Carlo Evaluation of Aerobraking Guidance Algorithms." NASA-JSC-IN-86-2115, September 1986.

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EXECUTIVE SUMMARY

REPORT NUMBER 88-2445

AUTHOR(S) MAJOR THOMAS E. SNOOK, USAF

TITLE THE SOVIET MIR SPACE STATION

I. Purpose: The purpose of this study was to determine if the Soviets' MIR space station represented a significant advance over the Soviets' predecessor Salyut 7 space station.

II. Approach: Three experts in space systems and operations were interviewed and established a general criterion of 26 percent increase in capability as a "significant advance." The study was organized into two sections, a physical comparison and a missions comparison.

III. Discussion:

The physical designs of Salyut 7 and MIR were reviewed. Salyut 7 was shown to be a capable spacecraft but noticeably limited in several areas. First the availability of only two docking ports limited the addition of spacecraft modules to increase on-orbit equipment. Secondly, the cramped space and manual operations in Salyut 7 limited the crew size to two and restricted crew efficiency and comfort. The MIR design reflects a fundamental change in design and operations. The MIR vehicle was designed as the core for a modular complex. MIR was shown to be primarily for command and control, and for more comfortable crew quarters. MIR has six docking ports to which specialized modules can be attached and support experiments. MIR is expected to support a crew of up to six persons. A sixfold increase in onboard computers, automation, and enhanced communications should significantly increase the crew's efficiency and comforts. The effects of these design differences between Salyut 7 and MIR were related to various mission capabilities.

Four mission categories for a space station were discussed: scientific, commercial, military and political. MIR was determined to be a significant improvement in capability to accomplish each of these four missions. The scientific, commercial and military capabilities were enhanced by the increased hardware and on-orbit manpower provided by the design changes. The political mission was enhanced by the space records and international participation provided.

IV. Conclusions: The MIR space station was determined to be a significant advance relative to the Salyut 7 space station. Key physical capabilities increased from 100 to 600 percent. The improved physical capabilities supported expanded capabilities for the scientific, commercial, military and political missions.

Chapter One

INTRODUCTION

BACKGROUND

The United States (US) has active civilian and military space programs. The Department of Defense (DOD), and especially the Air Force, has become increasingly dependent and committed to space systems. For example, the Air Force's budget for space operations grew 8.3 percent in 1987, 20.7 percent for 1988 and 24.7 percent for 1989 (1:F-15). The Soviet Union has also recognized the importance of space operations and has an enormous space program (5:1). As our potential adversary, we need to be knowledgeable of Soviet space operations. The intention of this paper is to inform on a segment of the Soviet space effort, their manned space station program. The specific purpose is to analyze the Soviets new space station, "MIR", relative to its predecessor, "Salyut 7" and determine if MIR represents a significant advance for the Soviets.

To begin, a space station is defined as an orbiting spacecraft to which other spacecraft regularly visit. The visiting spacecraft normally come from, and return to the earth. Under this definition, there have been nine space stations placed in orbit. Table 1 lists these spacecraft and their periods of operation. As shown, eight were of Soviet origin and one was from the US (3:81-85,185-188).

A question one might ask is, "What are the missions of a space stations?" A space station is essentially an orbiting laboratory. Thus, scientific research is an inherent mission of a space station. This scientific research produces knowledge which is useful in itself, but this knowledge is normally directed towards commercial and/or military applications (2:30-63). Although related, these three items; scientific, commercial, and military uses, are normally given as the missions for a space station (3:185-281). The Soviets also make considerable use of their space station for political purposes; therefore, political uses will be considered as a fourth mission (19:65).

NAME	PERIOD IN ORBIT	ORIGIN
Salyut 1	23 Apr 71 to 11 Oct 71	USSR
Salyut 2	3 Apr 73 to 28 May 73	USSR
Skylab	14 May 73 to 11 Jul 79	USA
Salyut 3	25 Jun 74 to 24 Jan 75	USSR
Salyut 4	26 Dec 74 to 3 Feb 77	USSR
Salyut 5	22 Jun 76 to 8 Aug 77	USSR
Salyut 6	29 Sep 77 to 28 Jul 82	USSR
Salyut 7	19 Apr 82 to present	USSR
MIR	19 Feb 86 to present	USSR

Table 1. Space Stations (3:81-85,185-188).

APPROACH

The Soviets have operated three generations of space stations. The first and second generations were known as "Salyut" spacecrafts. The first generation included Salyuts 1 through 5 and the second generation consisted of Salyuts 6 and 7. Overlapping with the operation of Salyut 7, the Soviets launched their third generation space station, MIR (19:1). The principal question of this study is, "Is the MIR space station a significant advance for the Soviet space program?" The approach in answering this question was to evaluate the third generation MIR space station against the second generation Salyut 7 space station. The study will begin with a physical comparison followed by an evaluation by mission. The evaluation will favor quantitative measures, but qualitative comparisons will also be included.

This chapter (Chapter 1) introduces the subject. Chapter 2 states the criteria for evaluation. Chapter 3 describes the physical features of Salyut 7 and MIR. Chapter 4 discusses the missions capabilities of each space station. Chapter 5 analyzes the physical features (Chapter 3) and the missions capabilities (Chapter 4) under the criteria (Chapter 2). Chapter 6 summarizes the results.

The MIR space station is determined to be a significant advance for the Soviet space program.

Chapter Two

CRITERIA

An initial step for this study is to quantify "significant advance". The criterion adopted was to establish a percentage number representing an increase in performance for a new space station versus the older space station. The percentage number was determined by averaging the values obtained from three experts, (considering myself as one expert). This percentage number is simply each expert's personal "rule of thumb", to which he gives noticeable attention on improved spacecraft capabilities. For example, if the current space station could do 100 experiments a month, how many experiments a month would you expect a new space station to accomplish to represent a significant advance? If the percentage number is 50%, then the new space station would have to do 150 experiments per month to represent a significant advance.

The experts interviewed were Mr. James Oberg and Mr. Ross McHenry. Mr. Oberg is an engineer for McDonnell Douglas at NASA Johnson Space Center and has written extensively on the Soviet space program. Mr. McHenry, is an engineer with over 20 years experience in manned space operations at the NASA Johnson Space Center. Mr. Oberg's opinion for a percentage number of a general nature representing a "significant advance" was 33 percent (21:--). Mr. McHenry's response number was 20 percent. My opinion was 25 percent (20:--). The average of these is 26 percent which will be used in this study. Mr Oberg and Mr. McHenry cautioned not to overrate this percentage value and to carefully consider non-statistical data in the assessment (20:--,21:--).

The evaluation of the physical capabilities will include direct reference to the criterion of 26 percent. The evaluation of mission capabilities will rely more on a logical application of the improved physical capabilities to enhance mission capabilities.

Chapter Three

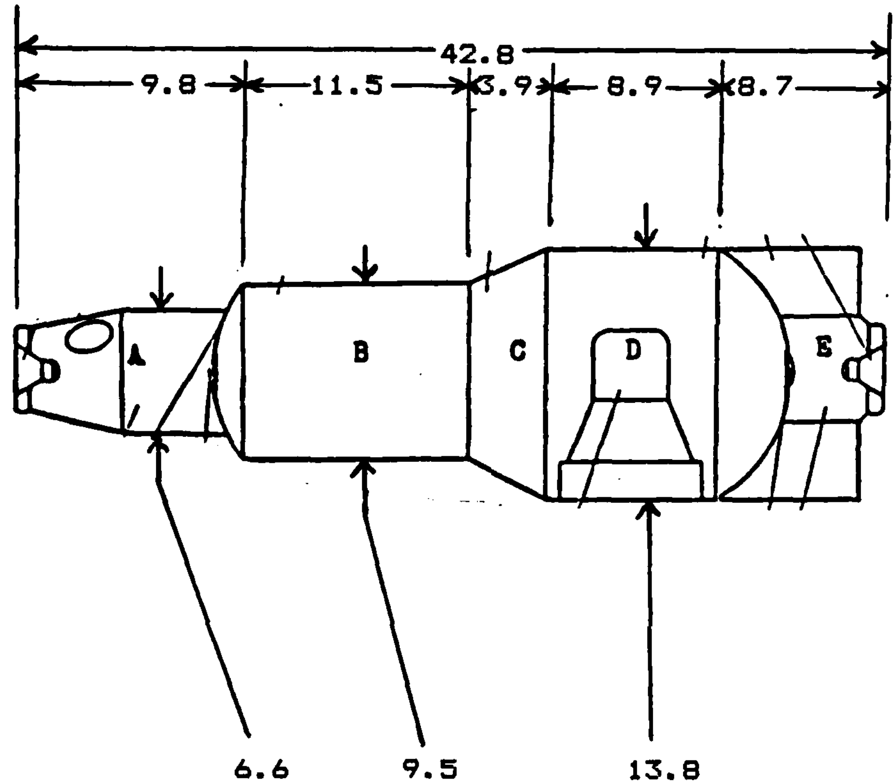
PHYSICAL DESCRIPTION - SALYUT 7 AND MIR

SALYUT 7

Salyut 7 is a cylindrical body of approximately 42.8 feet in length, 13.8 feet in diameter and weighs 41,700 pounds (3:184). This cylindrical body is assembled from three modules; a forward transfer module, a central work module and an aft transfer module. Figure 1 presents the basic shape and dimensions of these modules (19:I-21).

All of the modules are habitable and provide approximately 3,530 cubic feet of combined living space. Figure 1 shows that the central module is further subdivided into three sections; the small diameter command section (forward area), the larger diameter experiment section (aft area), and a conical intermediate section connecting the two (19:I-19). These will be discussed later.

Figure 2 is an isometric drawing of the Salyut 7 with two crew transfer vehicles docked (19:I-17). (The crew transfer vehicles used by the Soviets are called "Soyus T" spaceships.) This is an example of a complete orbiting complex. Figure 2 presents numerous key features of Salyut 7. First, note the two longitudinal axis docking ports to which the Soyus T vehicles are berthed. (The number and type of docking ports is critical to the operation of a space station as discussed later.) Also visible are distinctive booms and antennae on the forward and aft ends of Salyut 7 with similar gear on the Soyus T vehicles. These booms and antennae support rendezvous operations. (The rendezvous can be accomplished manually or automatically (3:185).) Also shown are the solar panels which provide most of the electrical power. These solar panels span 55.8 feet, have a total productive surface area of 548.8 square feet and produce approximately 4.0 kilowatts of electrical power (19:I-8).



Legend
Dimensions in feet

A Forward Module
B Central Module-Command Section
C Central Module-Intermediate Section
D Central Module-Experiment Section
E Aft Module

Figure 1. Salyut 7 External Dimensions (19:I-21).

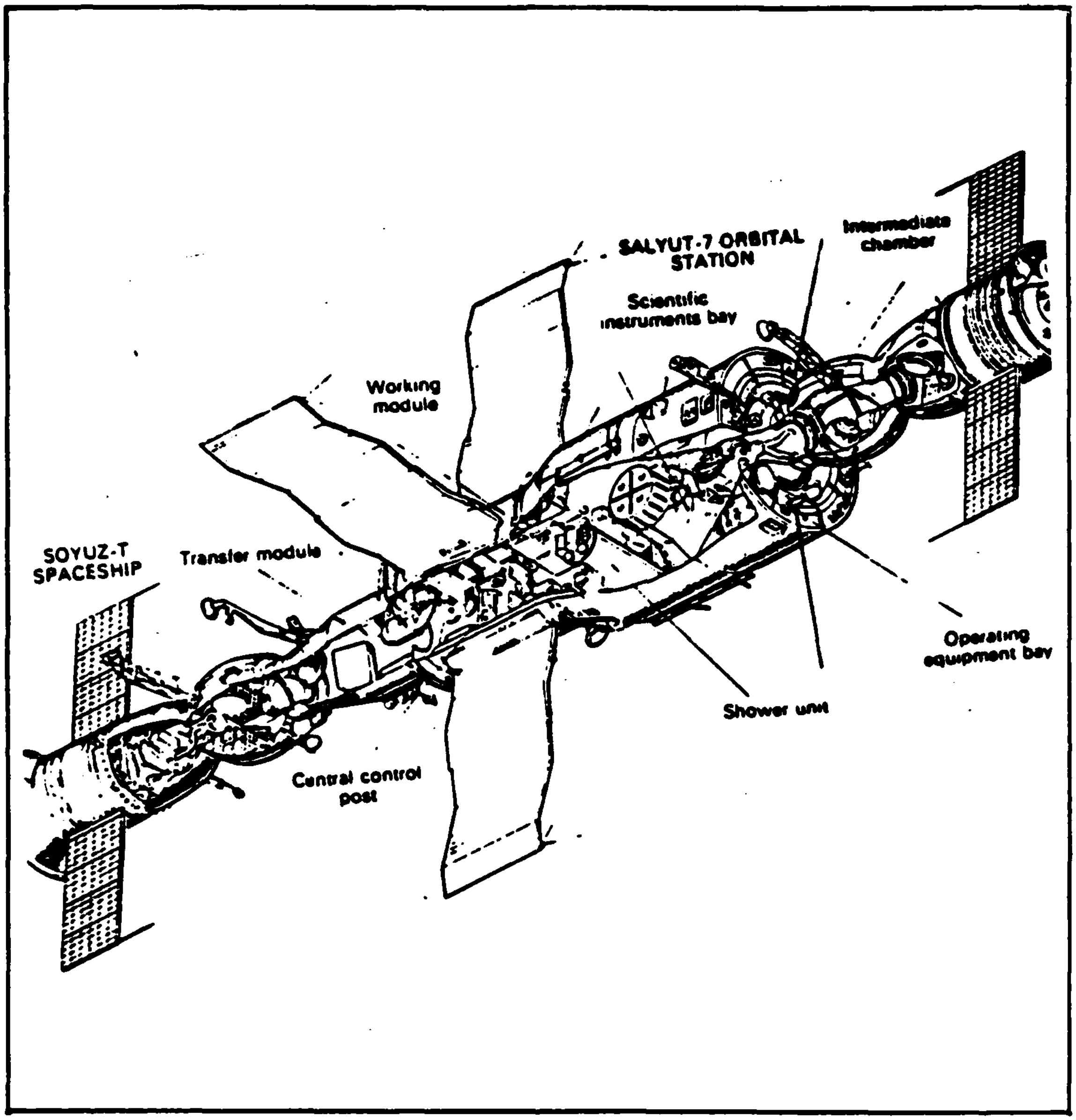


Figure 2. Salyut 7 Orbital Complex (19:I-17).

Salyut 7 - Forward Module

Figure 3 presents the internal configuration of Salyut 7 (19:I-8). (Note the two internal bulkheads that divide the vehicle into the three modules.)

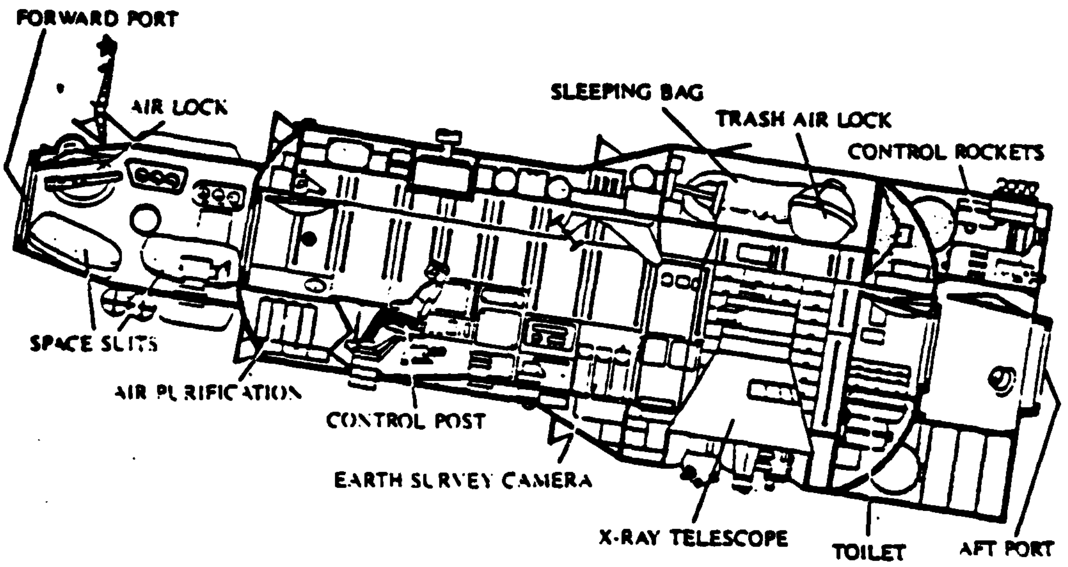


Figure 3. Salyut 7 - Internal Configuration (19:I-8).

The forward module is primary for crew transfer. Stored in the forward module are two space suits. These space suits are adjustable which permits their use by both the primary and visiting crews (3:185). Also shown is the air lock for access to the outside for spacewalks. The Salyut space stations were designed with seven specific "Posts" at which work can be performed. (Each Post has a seat, a folding or pull-out table, a lamp and access to particular equipment.) The forward module contains Posts 5 and 6 from which astro-orientation and other scientific equipment can be operated (19:I-19). The forward module has seven portholes for viewing and experiments. On the outside of the forward module are antenna and lights for docking (3:184).

Salyut 7 - Central Module

Figure 4 presents the internal layout of the command and intermediate sections of the central module (19:I-19).

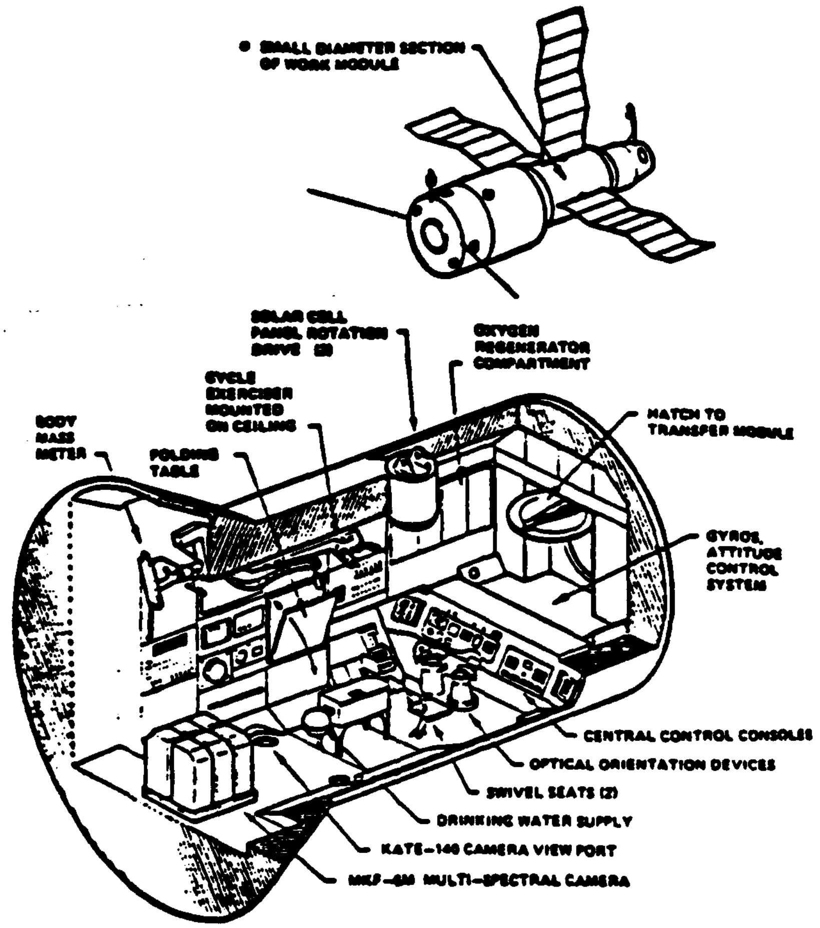


Figure 4. Salyut 7 Central Module - Command and Intermediate Sections (19:I-19).

Shown is a compact arrangement of control consoles, navigation equipment, exercise gear, life support systems, and camera instruments. The work locations (Posts) are not marked, but are described here. Post 1 is the main control station. It has two seats and faces the control consoles. Post 2 is further aft and is for astro-orientation and navigation. Between Posts 1 and 2 is a folding table which is used for food preparation, eating and doubles as a repair bench. Post 7 is to the side and controls the computer and water regeneration system. Equipment and instruments are arranged in standard racks along the walls (19:I-18).

Figure 5 presents the experiment section (19:I-39). This is the largest and most used area of the space station. Shown is the large X-Ray telescope used on Salyut 7, the sleeping bags, the trash disposal air lock, and the equipment racks. This area also includes a treadmill, food storage bins, a shower unit, and a bathroom facility. Post 3 is in this area and controls the scientific equipment. Post 4 is also in this area and serves medical experiments and photography (19:I-19). The central module has a total of 11 portholes (3:185).

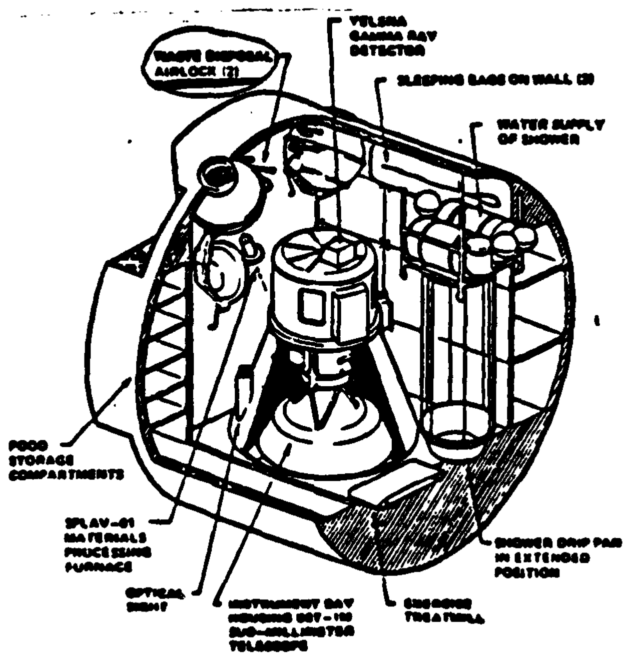


Figure 5. Salyut 7 Central Module - Experiment Section (19:I-39).

Salyut 7 - Aft Module

Figure 3 shows the aft module. The primary function of the aft module is to receive the unmanned "Progress" resupply spacecrafts (3:184). A Progress vehicle is launched and docked to the space station every three to six weeks (17:57). Also the aft module is used by any visiting cosmonauts. The aft module contains the resupply lines, a compressor unit for refueling, the spacecrafts main thrusters and some of the control rockets (3:184).

MIR

To minimize redundancy, the description of MIR will concentrate on those features which are significantly different from Salyut 7. This approach permits the following discussion to be presented along the external and internal configurations versus the module approach used for Salyut 7.

Mir - External Configuration

Figure 6 illustrates the external configuration of the MIR spacecraft (5:54). MIR is also assembled from three modules; a forward module, a central module, and an aft module. MIR is 41.7 feet in length, 13.8 feet in diameter and weighs 44,100 pounds (5:55). Like Salyut 7, all of the modules are habitable and provide approximately 4,590 cubic feet of combined living space. Of special note is that MIR has six docking ports; two on the longitudinal axis (one forward and one aft), and four lateral docking ports on the forward module. The solar panels span 97.4 feet, have a productive surface area of 817.8 square feet and produce approximately 10.0 kilowatts of electricity (5:54). Another modification to the forward module is the addition of a manipulator socket. This socket is to aid in transferring vehicles from the forward dock to a lateral dock (4:269). On the exterior of the center module are handrails which assist external vehicle activity (EVA). (Similar handrails were used on Salyut 7.) On the exterior of the aft module is a new antenna. This antenna is for a data link to a geosynchronous communications satellite to provide continuous communication with MIR (8:25). (Salyut 7 normally had direct communications to the ground controllers for only 20 minutes out of each 90 minute orbit (14:282).) MIR has a total of 25 portholes versus 18 on Salyut 7 which permits added viewing, photography and sensing (19:3).

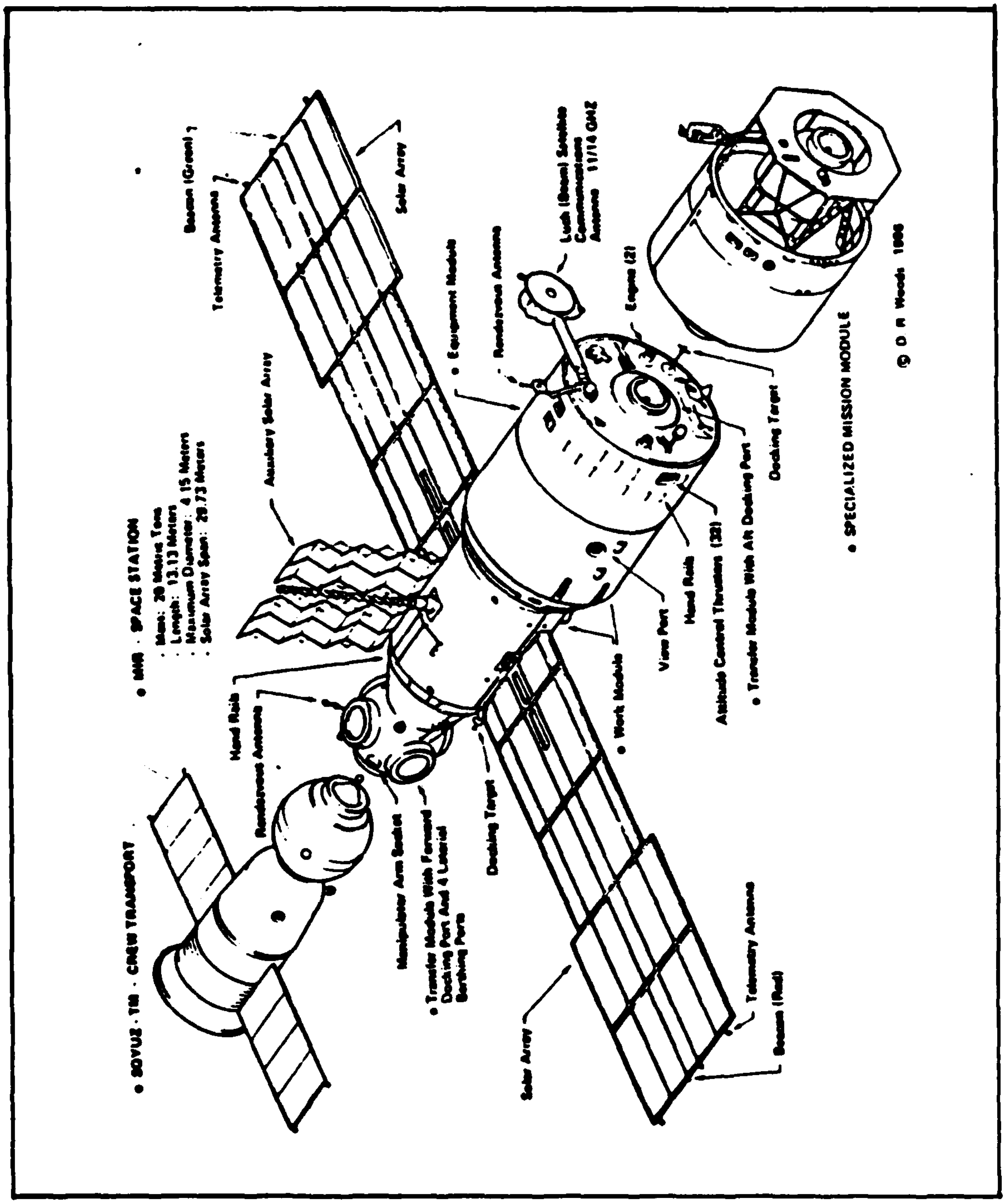


Figure 6. Mir External Configuration (5:54).

MIR - Internal Configuration

Figure 7 is a cutaway showing internal details of MIR (14:283). This figure illustrates a significant change in interior design of MIR relative to Salyut 7. The Soviets essentially designed MIR for vehicle control and crew living (19:I-3). (Specialized modules will be added at the many docking ports to provide the space and equipment for most experiments (19:I-5).) This change in design philosophy is most obvious in the aft portion of the central module. Note the addition of private cabins that are clearly separate from the work area. The large telescopes and camera of Salyut 7 are gone. The bicycle exerciser is stored under the floor. The treadmill was switched to a longitudinal position versus the lateral position on Salyut 7. (Cosmonauts on MIR can now view the control section and the many activities in that area as they workout, instead of spending hours staring at a blank wall (14:281)). In general, all types of "clutter" have been removed from the central module making it a more comfortable living areas versus being an experiment section as it was on Salyut 7 (19:I-2).

The British journal "Spaceflight", assessed that "Overall, MIR is 90 percent different from Salyut in the way that it is equipped." (12:104). This reflects a significant change, but does not imply a 90 percent increase in capabilities.

Cut-away view of Mir showing: 1. Base block. 2. Docked spaceship. 3. Adapter module. 4. Manipulator pocket. 5. Side docking units. 6. Docking systems' antenna. 7. Working module. 8. Working module's hatch. 9. Central control post. 10. Handrails. 11. Detachable panels of the interior. 12. Solar Cells. 13. Bicycle ergometer. 14. Working table. 15. Individual cabin. 16. Bathroom. 17. Wash-stand. 18. Satellite-communications antenna. 19. Axial docking unit. 20. Track simulator. 21. Air-lock chamber. 22. Engine with a roof. 23. Target. 24. Engine accessories compartment. 25. Hatch lid. 26. Viewport. 27. Viewport blend. Novosti

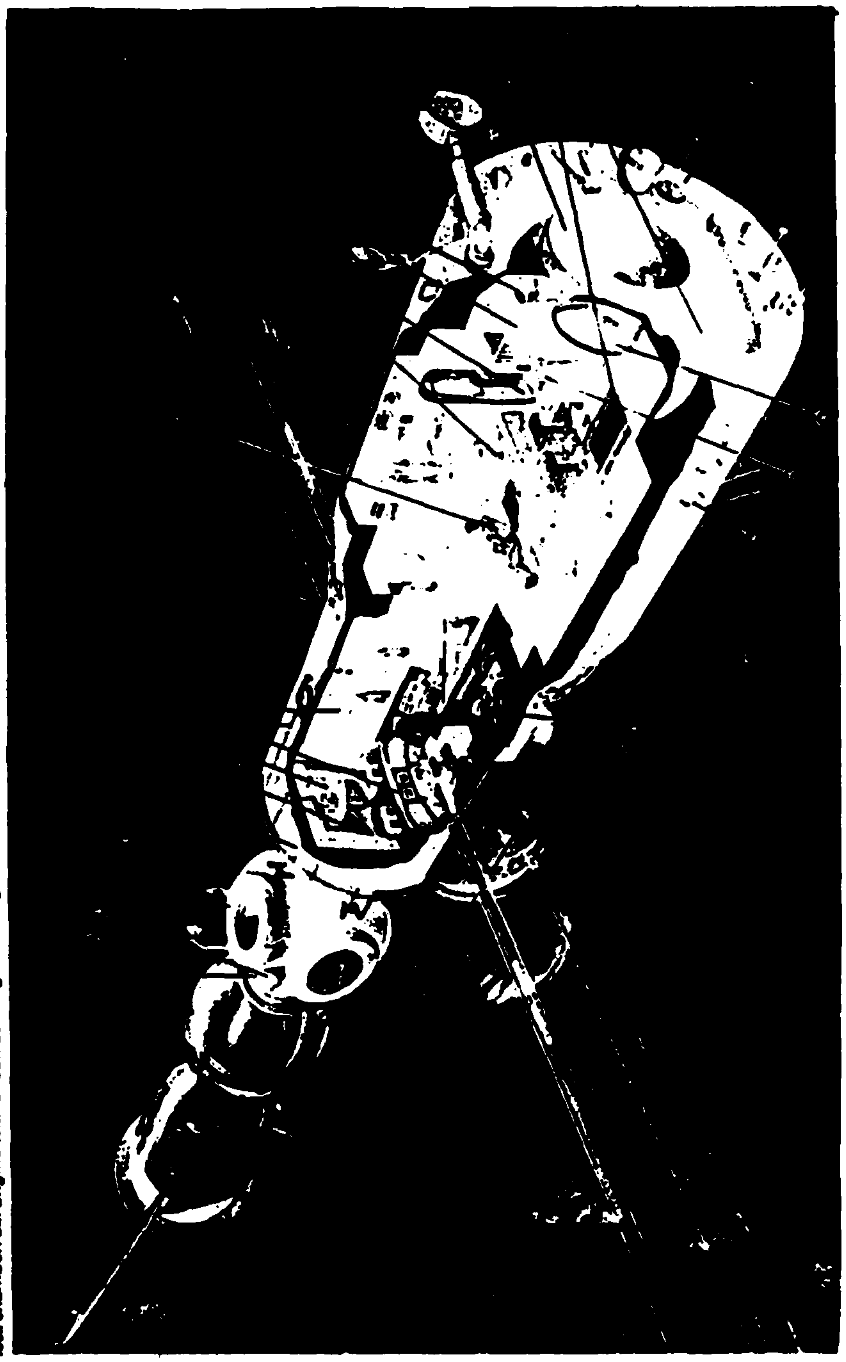


Figure 7. MIR Cutaway (14:283).

Chapter Four

MISSIONS COMPARISON - SALYUT 7 VS MIR

As stated in the introduction, space stations have four mission categories: (1) scientific, (2) commercial, (3) military and (4) political. This chapter will compare Salyut 7 and MIR along these mission categories. Most items discussed however will have effects on several or all of the mission categories because of the integrated nature of a space station.

SCIENTIFIC

Space activities are on the leading edge of technology. The open literature on the activities of Salyut 7 and MIR are dominated by scientific related data (21:--). Some areas of scientific research from space are earth observation (geophysics, atmospheric research, resource mapping), space observation (solar physics, astronomical research, radiation and magnetic field studies), manufacturing techniques (metallurgy and stress analysis) and medical research (space effects on man, drug research, etc.)(20:--). This paper will not analyze the detail of all these scientific fields, but will examine key differences between Salyut 7 and MIR which impact overall scientific research capabilities.

Scientific research in orbit is limited by two constraints: (1) the equipment required and (2) the manpower available (20:--). Figure 3 shows that in Salyut 7, the scientific equipment was concentrated in the experiment section of the central module. In operations, the Soviets would ship additional equipment to orbit on Progress resupply ships. The crew would transfer this equipment to the central module. Frequently, this equipment was installed and operated in already cramped space and in a make shift fashion (19:162). The Soviets recognized these problems and selected a different approach for MIR. The approach for MIR was to reserve the three modules of the MIR spacecraft and especially the central module for station command and control, and crew living quarters. (This was shown by Figures 6 and 7.) The Soviets package the scientific equipment in specialized modules which are launched separately and docked with MIR. The modules contain their own life support and power systems in addition to the scientific equipment and work stations from which to conduct the experiments (8:27). Examples of this are the astrophysics module known as Kvant and a science module designated as Kosmos. Figure 8 presents a Soviet drawing of MIR with a number of these modules (14:280). The Kvant module was docked with MIR in April 1987 (18:19). The Kosmos module was first used with Salyut 7 (4:30). With the addition of the four lateral berths on MIR, the capability to house and operate scientific equipment has been greatly expanded.

The other major limitation in conducting scientific experiments is the on-orbit manpower (20:--). The Salyut 7 was limited to a crew of two on a continuous basis, and occasionally supporting an additional three persons which normally visited for only 7 to 10 days (17:57). With the additional living space to be provided by the add on modules, MIR is expected to support a crew of up to six persons on a continuous basis (4:55).

In addition to simply increasing the numbers of persons in orbit, the Soviets have taken steps to increase crew efficiency (11:429). The Salyut 7 crews complained of spending too much time in controlling and maintaining the spacecraft and that little time remained for conducting experiments (19:III-4). The Soviets took two significant actions to decrease the space stations demand on the crew. First, they installed seven computers on MIR versus the one on Salyut 7. A primary function of these computers is to automatically command and control the spacecraft for most operations including docking (19:I-2). Second, nearly all equipment and systems onboard MIR were designed for easy removal and installation (19:I-2). The combination of these two changes significantly improved crew efficiency by essentially freeing the equivalent of one crewmember from operations and maintenance functions to research duties (4:220). (On Salyut 7 and MIR the Soviets schedule 8.5 hours of work each day (4:268).) These changes would of course also increase the man-hours available for activities in the commercial and military mission categories.

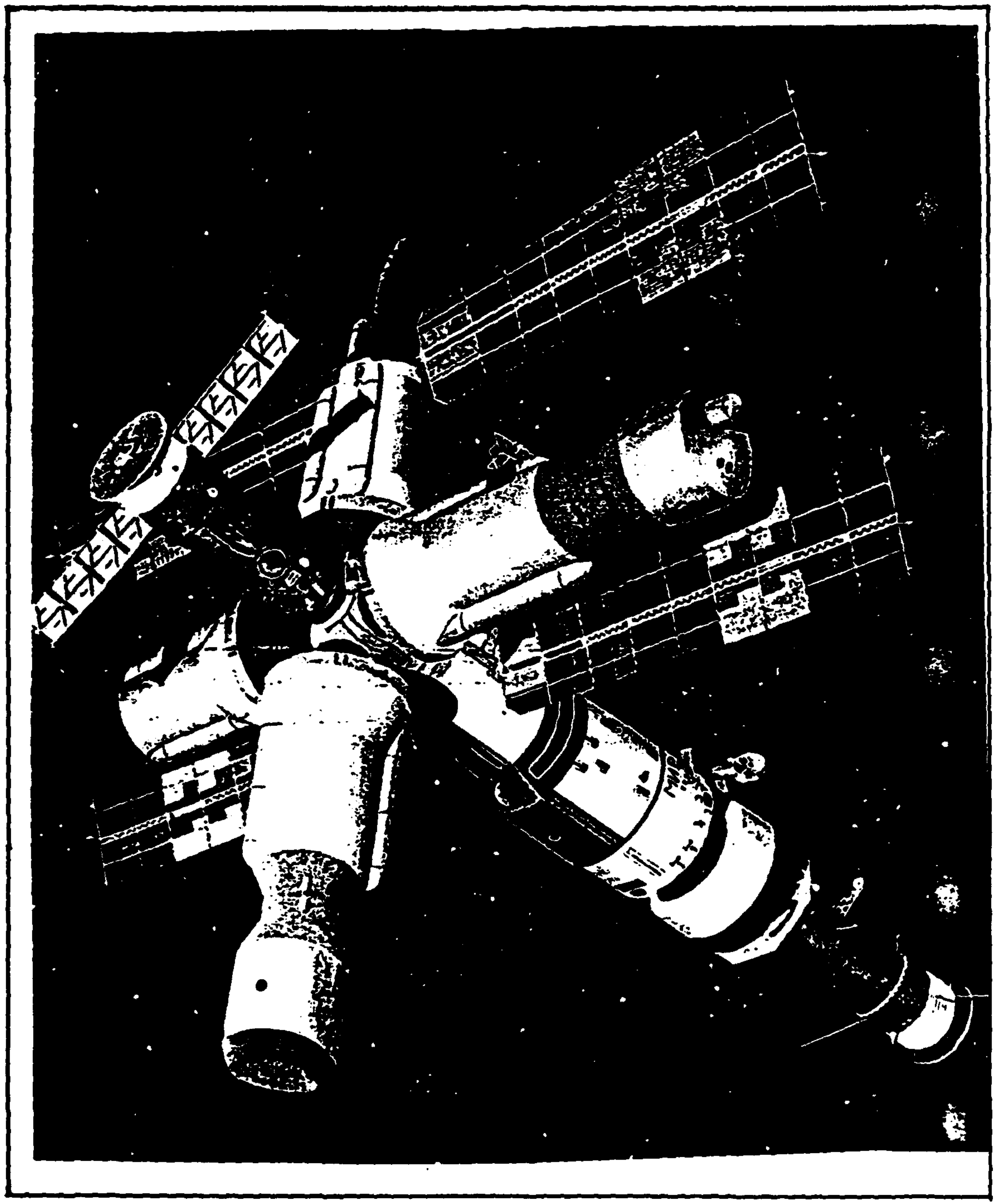


Figure 8. MIR Orbital Complex (14:280).

COMMERCIAL

Today, both the US and the Soviet Union use space for commercial applications such as communications, earth resources, and weather satellites. These commercial systems are very valuable, but are all information type systems. A goal of the Soviets is to advance their space station program into commercial space operations that would manufacture physical products for use on earth. More specifically, the Soviets have stated a goal of producing approximately 50 billion rubles worth of products annually in space by the year 1990 (4:269).

Salyut 7 supported numerous commercially oriented scientific experiments, but no direct commercial operations (3:269). MIR has not begun any commercial operations to date, but is better equipped to do so (6:17). MIR has a larger and more capable high temperature furnace to support metallurgical experiments or limited production (4:269). The solar panels on MIR are larger, more efficient and consequently provide 10 megawatts of electrical power, 150 percent more than on Salyut 7. The seven computers on MIR (versus the one on Salyut 7) are considered necessary to control larger scale experiments leading to limited commercial operations (4:269). These items are in addition to the increased mass, volume and manpower discussed earlier which are essential for commercial operations.

The advantages of space manufacturing are related to the nature of the space environment. Zero gravity is a key environmental condition of space. (A spacecraft in orbit about the earth is far from zero gravity in an engineering sense, however the term zero gravity will be retained because of its common usage.) Pre-commercial experiments in materials processing such as metallurgy and crystal growth exploit the zero gravity environment (4:270). Numerous medical experiments have been done with the hope of commercial use (4:267). Usually some exceptional purity or uniformity is sought under the zero gravity condition.

From Salyut 7 to MIR, the Soviets have significantly changed their spacecraft rendezvous procedure which reduces the disturbance of the zero gravity of the space station. On Salyut 7, both the space station and the approaching spacecraft fired their rocket engines to accomplish the rendezvous. For MIR, only the approaching spacecraft maneuvers, thus the zero gravity environment is better maintained. (Maintaining the zero gravity environment is considered essential for many potential commercial operations (4:268).) This reduced maneuvering by the space station also conserves fuel and thus reduces refueling requirements. This in turn allows the resupply spacecraft to increase its percentage of payload in support of commercial production (4:270).

In summary, Salyut 7 and MIR to date have not begun commercial operations. However, the Soviets have stated their goal of commercial manufacturing in space. The design and operational concept of MIR have been directed to support commercial applications. MIR has significantly greater commercial capability than Salyut 7.

MILITARY

The Soviets argue that they conduct no military related missions from space (16:1-3,13:364). Consequently, the open literature contains considerable less information on military operations. In the Salyut series of space stations, the Soviets alternated between the scientific mission and the military mission. Salyuts 1,4, and 7 were equipped for scientific experiments. Salyuts 2,3,5 and 6 were equipped for military related experiments (i.e. ocean surveillance, land reconnaissance, etc.)(4:169,9:51-58).

Certainly the Soviets will use the MIR space station for military missions. In general, the many expanded capabilities for MIR discussed earlier would only enhance the Soviets position to conduct military missions. The added docking ports for MIR will likely be used to receive specially designed modules for military applications (9:58). The additional portholes, most of which are oriented towards the earth, are considered useful for ocean and land surveillance of military forces (9:58). Perhaps, MIR could even serve as a manned eye-in-the-sky command post or battle station. In any event, MIR represents a significant advance for the military mission as compared to the Salyut space stations (9:58).

POLITICAL

The Soviets exploit their Space Program, including their manned space station efforts, for political benefits. They accomplish this by a variety of means. One is the establishment of numerous records and firsts in space. A key record the Soviets pride themselves in is the manned flight duration record. Table 3 lists the history of this record which is dominated by missions to space stations (4:29-32).

The Soviets also highly publicize the participation in their space flights by allies, third world countries and even western countries. Table 4 list the non-Soviet participants through 1987 (4:29-32). A Bulgarian and a Frenchman are planned to participate in 1988 on missions to MIR (15:425).

The Soviets politicized the naming of their third generation space station with the title of MIR. MIR is Russian for peace. The Soviets point toward their "Peace" space station in contrast to the US "Star Wars" space program (16:1-3,9:52).

Considering the increased physical capabilities, manning capabilities and intentions of the Soviets to use space for political benefits; MIR represents a significant advance for the political mission.

DATE	DURATION DAYS:HOURS	FLIGHT	SPACE STATION	NAME	COUNTRY
12 Apr 61	00:02	Vostok 1	no	Gargarin	USSR
6 Aug 61	01:01	Vostok 2	no	Titov	USSR
11 Aug 62	03:22	Vostok 3	no	Nikolayev	USSR
14 Jun 63	04:23	Vostok 5	no	Bykousky	USSR
21 Aug 65	07:23	Gemini 5	no	Cooper	USA
4 Dec 65	13:19	Gemini 7	no	Borman	USA
1 Jun 70	17:17	Soyuz 9	no	Nikolayev	USSR
25 May 73	28:01	Skylab 2	Skylab	Conrad	USA
28 Jul 73	59:11	Skylab 3	Skylab	Bean	USA
16 Nov 73	84:01	Skylab 4	Skylab	Carr	USA
10 Dec 77	96:10	Soyuz 26	Salyut 6	Romanenko	USSR
15 Jun 78	139:14	Soyuz 29	Salyut 6	Kovalyonok	USSR
25 Feb 79	175:00	Soyuz 32	Salyut 6	Lyakhov	USSR
9 Apr 80	184:19	Soyuz 35	Salyut 6	Popov	USSR
13 May 82	211:08	Soyuz T-5	Salyut 7	Berezovoi	USSR
8 Feb 84	236:23	Soyuz T-10	Salyut 7	Kizim	USSR
5 Feb 87	326:02	Soyuz TM-2	MIR	Romanenko	USSR

Table 2. World Manned Spaceflight Endurance Record (4:29-32).

DATE	FLIGHT	SPACE STATION	NAME	COUNTRY
27 Jun 78	Soyuz 30	Salyut 6	Hermaszewski	Poland
26 Aug 78	Soyuz 31	Salyut 6	Jahn	E. Ger.
10 Apr 79	Soyuz 33	Salyut 6	Ivanor	Bulgar.
25 May 80	Soyuz 36	Salyut 6	Farkas	Hungary
23 Jul 80	Soyuz 37	Salyut 6	Tuan	Vietnam
18 Sep 80	Soyuz 38	Salyut 6	Mendez	Cuba
22 Mar 81	Soyuz 39	Salyut 6	Gurragcha	Mongol.
14 May 81	Soyuz 40	Salyut 6	Prunaria	Romania
24 Jun 82	Soyuz T-6	Salyut 7	Chretien	France
3 Apr 84	Soyuz T-11	Salyut 7	Sharma	India
25 Jul 87	Soyuz TM-3	MIR	Faris	Syria

Table 3. Non-Soviet Cosmonauts (4:29-32).

Chapter 5

ANALYSIS

This chapter includes a quantitative analysis of the physical features of Salyut 7 and MIR. This is followed by a qualitative analysis of the mission capabilities of Salyut 7 and MIR. The missions analysis will be a logical application of the physical differences for their impact on mission capabilities.

TECHNICAL ANALYSIS

Table 4 presents a direct comparison of physical features of Salyut 7 and MIR, including the percentage of change. Chapter 2 established a general criterion of a 26 percent increase as representative of a significant improvement. The differences presented in Table 4 are based on a direct comparison of the core Salyut 7 and core MIR spacecrafts.

The differences presented in Table 4 become even greater if a complete MIR complex is considered. For example, the mass of MIR is only 5.8 percent greater than for Salyut 7. However, considering the maximum module mass for docking of 44,050 pounds, MIR has the potential to expand to a total mass of 279,400 pounds. This is 115.3 percent greater than Salyut's maximum mass of 129,800 pounds (4:53-65).

The overall benefits to MIR are frequently much greater than the straight percentage increases might suggest. This is to say that not all things are linear. One example of this is living space. The 30.0 percent increase in living space in MIR was achieved by the removal of most scientific equipment from the core vehicle. (Recall that the length and diameter of Salyut 7 and MIR are nearly identical.) The transfer of the scientific equipment not only provided more room, but made that added volume a more effective living space. The cosmonauts have reported greatly improved living conditions on MIR as compared to Salyut 7 (19:I-76).

ITEM	SALYUT 7	MIR	PERCENT CHANGE
Original Mass (pounds)	41,700	44,100	+5.8
Original Living Space (cubic feet)	3,530	4,590	+30.0
Design Life (years)	3	10	+233.3
Docking Ports	2	6	+200.0
Electrical Power (kilowatts)	4	10	+150.0
Crew Size	3	6	+100.0
Onboard Computers	1	7	+600.0

Table 4. Physical Comparison - Salyut 7 vs MIR (4:53-65; 19:I-1 - I-21).

From the perspective of a maximum size orbiting complex, (like the mass example), the capability for more add-on modules significantly increases the total available living space. The maximum for a Salyut 7 complex is approximately 10,590 cubic feet and for a MIR complex it is approximately 25,770 cubic feet for a 143.3 percent increase (4:53-65). Similarly for electrical power, the add-on modules will have their own solar panels, thus the MIR complex would have considerably more than a 150 percent increase in electricity relative to the Salyut 7 complex.

For the variables of crew size and onboard computers there are some interconnections. The additional computers essentially frees one crewmember to do research or non-operations and maintenance duties. Salyut 7 had approximately 1.5 crewmembers free for research, whereas MIR will have approximately 5 crewmembers free for research, an increase of 233.3 percent.

The MIR space station clearly represents a significant improvement in the area of physical capabilities.

MISSIONS ANALYSIS

Scientific

The significant expansion of the on-orbit equipment and manpower provided by MIR should produce considerable scientific benefits. The Kvant module is surely only the first of several science modules to be deployed. More pure scientists are likely to start working in space. These scientist will devise, conduct and analyzing their experiments in orbit, accelerating the pace of development. The long duration flights suggest that MIR may be used for a launch platform for manned exploratory missions to Mars and to the asteroids. MIR certainly is a significant advance for the scientific mission, which will form the base for the other missions.

Commercial

The on-orbit facilities provided by MIR and Salyut 7 (they are both still in orbit) have the Soviets uniquely positioned to capitalize on any commercially profitable space process developed in the East or West. When a product is developed, the Soviets can build a production module and deploy it to MIR. Operation by a skilled worker and not a highly-trained cosmonaut or scientist is likely. The already production-line approach of the Soviets to their space program supports a quick transition to commercial operations.

Military

The expanding Soviet presence in space provided by the added facilities of MIR relative to Salyut 7 will carry definite military benefits. The army axiom of "He who commands the high ground, commands the battle," is surely true for space as well as on Earth. The build up of the MIR complex, even for scientific or commercial applications, provides a base for space military operations. Certainly militarily dedicated modules will be built and deployed to MIR. The preponderance of military officers in the Soviet cosmonaut corps will probably continue.

Political

The added facilities provided by MIR permits the Soviets to have a political bonanza relative to Salyut 7. The added comforts and efficiencies of MIR enables the Soviets to continue their campaigns to set space records. The enlarged crew size and expanded skill areas (like scientist only) permits the Soviets to mount aggressive, multinational (East and West), manned spaceflight missions. The publicity from a manned Mars missions would be outstanding. The political benefits of MIR could be as important as any of the other missions.

Chapter Six

SUMMARY AND CONCLUSIONS

SUMMARY

The objective of this study was to determine if the Soviet MIR space station represents a significant advance over its predecessor, the Salyut 7 space station. The physical designs of Salyut 7 and MIR were reviewed. Salyut 7 was shown to be a capable spacecraft but noticeably limited in several areas. First the availability of only two docking ports limited the addition of spacecraft modules to increase on-orbit equipment. Secondly, the cramped space and manual operations in Salyut 7 limited the crew size to two and restricted crew efficiency and comfort. The MIR design reflects a fundamental change in design and operations. The MIR vehicle was designed as the core for a modular complex. MIR was shown to be primarily for command and control, and for more comfortable crew quarters. MIR has six docking ports to which specialized modules can be attached and support experiments. MIR is expected to support a crew of up to six persons. A sixfold increase in onboard computers, automation, and enhanced communications should significantly increase the crew's efficiency and comforts. The effects of these design differences between Salyut 7 and MIR were related to various mission capabilities.

Four mission categories for a space station were discussed: scientific, commercial, military and political. MIR was determined to be a significant improvement in capability to accomplish each of these four missions. The scientific, commercial, and military capabilities were enhanced by the increased hardware and on-orbit manpower provided by the design changes. The political mission was enhanced by the space records and international participation provided.

A criterion of 26 percent change in physical capability or feature was established as an indicator of significant improvement for a space station. A comparative analysis showed most physical features improved 100 to 600 percent.

CONCLUSIONS

The MIR space station was determined to be a significant advance relative to the Salyut 7 space station. Key physical capabilities increased from 100 to 600 percent. The improved physical capabilities supported expanded capabilities for the scientific, commercial, military and political missions.

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